

Technical Papers by IBM Authors Published Recently in Other Journals

Absolute Contrast Enhancement, J. D. Armitage, A. W. Lohmann and R. B. Herrick, *Applied Optics* **4**, No. 4, 445-451 (April, 1965).

The basic idea of photographic masking is discussed, and two new methods for producing such masks are described. The conditions necessary to justify application of modulation transfer theory to the process are specified, and the theory is applied to demonstrate that it is possible to obtain a modulation transfer function greater than unity for a band of spatial frequencies. Experimental verification is described.

An Algorithm for the Machine Calculation of Complex Fourier Series, J. Cooley and J. W. Tukey,* *Mathematics of Computation* **19**, No. 90, 297-301 (April, 1965).

Some generalizations by I. J. Good of Yates' methods for the calculation of the interaction of a 2^m factorial experiment are applied here to the calculation of complex Fourier series. Instead of the N^2 operations required by a direct evaluation, the present algorithm requires only $N \log N$ operations, where N is the number of data points.

* Bell Telephone Laboratories, Murray Hill.

Algorithms for Traffic-Signal Control, L. A. Yardeni, *IBM Systems Journal* **4**, No. 2, 148-161 (1965).

Algorithms for the design of traffic-signal progressions for fixed-time control are described. Least-squares and minimax fits are used to derive solutions for given volume requirements within specified limits of speed and cycle time. The algorithms have been programmed for processing on a digital computer, thus reducing the initial design time considerably and leading to solutions that are superior to manually derived designs.

Analytical Kinematic Synthesis by Finite Displacements, J. T. Wilson, III, *Transactions of the ASME Journal of Engineering for Industry* **87**, Series B, No. 2, 161-169 (May, 1965).

One method to synthesize plane mechanisms is by graphically constructing the circle point and center curves for a prescribed motion. This paper presents an analytic method for determining these curves in Cartesian coordinates for both plane and space mechanisms. The solutions to these curves are not transcendental and may be programmed on a computer.

Another Criterion for Significance, Arthur J. Sable, *The Philosophical Forum* **22**, 33-42 (1964-1965).

A formulation, Criterion M, is proposed for a test of significance of sentences. Criterion M is based on a logical relationship of significant sentences to observation-sentences, and overcomes difficulties of earlier formulations which satisfy this empiricist condition. Criterion M is subject to qualifications of finiteness which do not limit its applicability to a large class of statements of natural languages.

The Approach to Equilibrium of a Neutron Gas, C. S. Shapiro and N. Corngold,* *The Physical Review* **137**, A1686-A1696 (March 15, 1965).

The authors have calculated the relaxation constants (time eigenvalues) associated with the time-dependent Boltzmann equation for the relaxation of a neutron gas in contact with a heat bath (moderating material). The eigenvalues were calculated by explicit and implicit matrix-methods, and for monatomic gas and crystalline models of the moderator. The discrete eigenvalues were found to lie in a finite piece of the λ -axis. The results strongly suggest that in many crystalline moderators, only the fundamental eigenvalue exists. In these cases, the approach to equilibrium is not exponential.

* Brookhaven National Laboratory.

Austauschwechselwirkung über die Leitungselektronen in Lanthanid-Halbleitern (Exchange Interaction via Conduction Electrons in Lanthanide Semiconductors), S. Methfessel, *Zeitschrift für angewandte Physik* **18**, No. 5/6, 414-432 (April, 1965).

Ferro- and anti-ferromagnetism in the lanthanide metals or in their metallic compounds are explained by indirect exchange due to polarized conduction electrons, since the magnetic $4f$ energy levels have a small extension. The semiconducting NaCl compounds of the divalent europium with elements of the 6th group, on the other hand, are ferro- or anti-ferromagnets which nearly ideally satisfy the conditions of localized Heisenberg exchange. By doping and partially replacing the divalent Eu by trivalent Gd, which has the same magnetic ground state $^8S_{7/2}$ of the $4f$ -electrons, the dependence of the exchange interaction on the population of the conduction band can be investigated.

Basic Design of Spring Clutches, V. W. Rudnickas and R. A. Fine, *Machine Design* **37**, No. 11, 182-186 (May 13, 1965).

This article describes the basic design, types and forms, design considerations, and dynamic effects of spring clutches.

Bourdon Gauge Determination of Chemical Equilibrium in the Ge-Cl₂ System, T. O. Sedgwick, *Journal of the Electrochemical Society* **112**, No. 5, 496-499 (May, 1965).

Bourdon gauge pressure measurements of samples of GeCl₃(g) and GeCl₄(g) plus Ge(s) have been made in the temperature range 300°-1300°K. The pressure change of pure GeCl₄ as a function of temperature indicates that it does not dissociate up to 1300°K. The pressure vs temperature behavior of GeCl₃(g) plus Ge(s) is described by the equilibrium $\text{Ge}(s) + \text{GeCl}_4(g) \rightleftharpoons 2\text{GeCl}_3(g)$. The standard enthalpy, ΔH° , and entropy, ΔS° , of reaction at 723°K were found to be 34.9 kcal and 46.7 eu, respectively.

Character Recognition by Incoherent Spatial Filtering, J. D. Armitage and A. W. Lohmann, *Applied Optics* **4**, No. 4, 461-467 (April, 1965).

The character recognition method described here is based on the principle of incoherent spatial matched filtering. The input to this matched filter is not the unknown character itself but its Fraunhofer diffraction pattern. The intensity distribution in this diffraction pattern is insensitive against shifting of the unknown character, avoiding the need for character registration. The incoherent matched filter is easier to implement than the coherent matched filter, since only binary rather than continuous-tone masks are required. The theory and some experiments are discussed and compared with other optical character recognition methods.

Characteristic Impedances of Generalized Rectangular Transmission Lines, H. Guckel, *IEEE Transactions on Microwave Theory and Techniques* **MTT-13**, No. 3, 270-274 (May, 1965).

The impedance of the generalized strip transmission line is computed by variational methods. The use of an upper bound and lower bound approximation yields an average impedance as well as a known maximum error. The one-dielectric microstrip line is treated as a limiting case. Losses are considered. Results include those problems that have been solved elsewhere by conformed mapping techniques as special cases.

The Circulation Pattern of One Technical Library, P. M. Strain, *Special Libraries* **56**, No. 5, 312-317 (May/June, 1965).

Special library circulation is different from that of public or university libraries, and special library administrators need more information about actual circulation relationships to make rational decisions relating to their own operations. Very little information on circulation in special libraries is published to serve as a guide to administrators. This study of the circulation relationships in one technical library is contributed to encourage further publication and study.

Une Classe de Processus Stochastiques Homothétiques à soi; Application à la loi Climatologique de H. E. Hurst, (A Class of Self-similar Stochastic Processes: Application to the Climatological law of H. E. Hurst), B. B. Mandelbrot, *Comptes Rendus de l'Académie des Sciences de Paris* **260**, No. 12, 3274-3277 (March 22, 1965).

A brief statement of the definition of a new class of self-similar stochastic processes is given. Application is made to the representation of long hydrological series and to the problem of the design of river dams.

Computer Channel Interference Analysis, W. Chang and D. J. Wong, *IBM Systems Journal* **4**, No. 2, 162-170 (1965).

This paper develops a queuing model that analyzes the capabilities of a low speed data channel for real-time data inputs. The model yields estimates of waiting, service, and over-all transit times. Low speed channel throughput can be increased by multiplexing low speed devices. It is assumed that the multiplexing operation employs common registers, the contents of which are saved at initiation and restored at completion of service for all outstanding requests. The model takes into account pre-emptive interference from high speed data channels.

Computer Voice Output, G. E. DuBois, *IEEE International Convention Record*, pp. 33-40 (1965).

Immediate access to computer information is necessary for its most effective use. To achieve more immediate access, a Voice Answer Back unit (VAB), with a vocabulary of 256 words and an output capacity of 200 simultaneous messages, has been developed. To maintain a uniform machine time, a method was devised for altering the length of words to fit machine time slots. The voice-output device can assemble messages with computer control; requests can be made and answers received on a standard dial telephone.

A Computer-Oriented System L. F. Knappe, *Mechanical Engineering* **87**, No. 5, 35-40 (May, 1965).

This article describes the development of an engineer-computer mechanical design system called COMMEND (Computer-Aided Mechanical Engineering Design). The initial system is restricted to the design of planar or equivalent planar mechanisms and implemented on presently available computer equipment. The article discusses the problems encountered in utilizing a computer in the mechanical design process and the system approach taken for this project. Design system programs are discussed along with examples. Anticipated benefits of the design system are also reviewed.

Concepts for a Central Flight Management System for the Supersonic Transport, J. H. Crenshaw and J. R. Riddle, *IEEE Transactions on Aerospace and Navigational Electronics* **ANE-11**, No. 4, 278-284 (December, 1964).

The supersonic transport offers many benefits in passenger confidence and convenience; however, it poses new problems in economy and safety in flight. Recent advances in microminiature technology make possible applications of digital data processors to the solution of these problems. The paper includes a discussion of the functions of navigation, flight control, flight management, data link and in-flight recording and maintenance. Microminiature circuit technology is also described as applied to the central flight management computer. Representative organizations are presented for several alternate processors.

The Construction of Discrete Dynamic Programming Algorithms, M. Held and R. M. Karp, *IBM Systems Journal*, 4, No. 2, 136-147 (1965).

Certain sequencing and scheduling problems are formulated as shortest-route problems and treated in a uniform manner by dynamic programming. Computational considerations are discussed.

Correlation Energy in Atomic Systems. III. Configurations with 3d and 4s Electrons, E. Clementi, *Journal of Chemical Physics* 42, 2783-2787 (April 15, 1965).

The correlation energy for systems containing 3d and 4s electrons has been examined making use of recently obtained Hartree-Fock energies for the elements from K to Zn. In addition to the expected pair correlation between 3d electrons, a large extrashell correlation has been found. These results make it desirable to re-examine the simple correlation model previously put forward. The relativistic correction for the elements in consideration has been discussed.

Defect Interactions and Precipitation in Semiconductors,† R. A. Swalin* and R. D. Weltzin, *Progress in Solid State Chemistry* 2, 175-215 (1965).

The observed kinetics of precipitation were examined in conjunction with various theories of the process for a few semiconductor systems which have been investigated in detail. The extraction of information regarding nucleation from precipitation data is discussed. Finally, it is shown how precipitation studies may provide information concerning the formation of certain defect complexes.

† Work performed at the University of Minnesota.

* University of Minnesota.

Design with Computers, M. A. Howard, *Mechanical Engineering* 87, No. 5, 31-34 (May, 1965).

A computer program concept is described that enables the engineer-designer to utilize a computer in performance of repetitive design and analysis calculations for mechanical components. The program logic is designed to accept component functional parameters and/or optional physical size parameters or operating conditions to provide information for part drawing specifications, quality assurance information and analysis data for evaluating the design.

The Design and Implementation of Automated Military Information Systems, J. H. Bryant and M. A. Todd, *IEEE Transactions on Military Electronics*, MIL-9, No. 2, 148-152 (April, 1965).

It is suggested that the optimum approach to the design and development of automated military information system lies somewhere between the "turn-key" and the "job shop" approaches. This approach has been referred to as the "evolutionary" approach. By careful planning and adequate management and technical control, it is possible to maintain system integrity; to provide a system which is responsive to the user, is reasonably flexible and adaptive to change; and to incrementally increase the operational capabilities performed in support of the staff. This can be ac-

complished through a step-by-step development of general purpose control programs and information-handling programs followed by application of these tools to specific tasks. In parallel with the application of these, special purpose programs can proceed in such a fashion as to allow them to be added to the system within the framework of the system programs. The amount of lead time required and the complexity of management and technical controls present the major difficulties. There are, though, many advantages; the use of general purpose programs provides for rapid response to many operational requirements which arise. In the long run, it will be most economical in programming costs. It provides incremental capabilities which can be gradually absorbed with minimum staff disruption and which can be incrementally evaluated. It maintains system integrity and extends the range of applicability to varying operating environments.

Effect of Deep Levels on the Optical and Electrical Properties of Copper-Doped GaAs p-n Junctions, T. N. Morgan, M. Pilkuhn,* and H. Rupprecht,* *The Physical Review* 138, A1551-A1561 (May 31, 1965).

Three types of GaAs p-n junctions containing diffused copper impurities were fabricated and studied. Careful investigation of their electrical characteristics and optical emission spectra were carried out over a wide range of current between 4° and 300°K. Broad emission peaks near 1.34, 1.29, and 1.06 eV (at low temperatures) are identified with transitions involving the interstitial copper donor and the first and second substitutional copper acceptor levels having binding energies of $E_c - E_{\text{donor}} = 0.07$ eV and $E_{\text{acceptor}} - E_v = 0.18$ and 0.41 eV, respectively. A similar peak near 1.00 eV is attributed to an unidentified donor level lying 0.5 eV below the conduction band. External quantum efficiencies were generally low, indicating the presence of an appreciable amount of nonradiative recombination. The existence of impurity conduction in the copper donor band of graded diodes containing large concentrations of copper ($> 6 \times 10^{18} \text{ cm}^{-3}$) is deduced from the disappearance at 77°K of all emission peaks except that at 1.34 eV. These diodes exhibited negative resistance ($dV/dI \lesssim 0$) above a breakdown voltage of 10 to 20 V. Alloy diodes in similar material showed negative resistance of the tunneling type ($dI/dV \lesssim 0$) above 0.3 V at room temperature. Some of the centers frequently seen in laser-type diodes by their emission near 1.0 eV and by their effects on capacitance are shown not to be due to copper.

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Electron Spin Resonance of Donor Centers in Beryllium Oxide, O. F. Schirmer,* K. A. Müller and J. Schneider,** *Physik der kondensierten Materie* 3, No. 4, 323-334 (1965).

The ESR spectra of two deep centers found in irradiated BeO crystals and powders, respectively, are reported and analyzed. They are due to electrons trapped at substitutional boron (B^{++}) and fluorine (F^-) ions as concluded from the hf interaction of the unpaired electron with the respective nuclei. The boron center revealed a static, the fluorine center a dynamic Jahn-Teller effect between 77°K and 300°K. In both cases, the unpaired electron was found to be localized in nonaxial orbitals, which is shown to be consistent with the direction of the polar field of the

crystal structure. The strong localization of the electron is contrasted to the behavior of donor electrons in other II-VI compounds, which are highly delocalized.

* Institut für Elektrowerkstoffe der Fraunhofer Gesellschaft, Freiburg im Breisgau, Germany.

** Physikalisches Institut der Universität Freiburg, Freiburg im Breisgau, Germany.

Electronic Effect in the Third-Order Elastic Constant C_{456} of n-Germanium, J. J. Hall, *The Physical Review* **137**, A960-A961 (February 1, 1965).

The doping of germanium with $\sim 3 \times 10^{19}/\text{cm}^3$ arsenic atoms has been observed to change the magnitude and reverse the sign of the third-order elastic constant C_{456} . Room-temperature measurements of the change of C_{456} and of the change of the shear modulus C_{44} upon doping are reported for two degenerate samples relative to a pure sample. By attributing these impurity effects to the electronic mechanism proposed by Keyes, the shear deformation potential constant Ξ is found to be 17.0 ± 0.2 eV, and the carrier densities of the degenerate samples are determined, in excellent agreement with the results of transport measurements.

Evidence of Vacancy Clusters in Dislocation-Free Float-Zone Silicon, T. S. Plaskett, *Transactions of the Metallurgical Society of AIME* **233**, No. 4, 809-811 (April, 1965).

A striated structure perpendicular to the growth axis was observed by the copper-decoration technique in dislocation-free, float-zoned silicon crystals. The striations, which were spaced about 100μ apart, fitted the relationship $d = f/\omega$, where d is the spacing, f is the growth rate, and ω is the crystal rotation rate. Each stria was resolved into an array of starlike precipitates of copper. The structure was not found at the surface for a depth of about 1.5 mm, or in a region of similar width ahead of a dislocation network. The structure is postulated to consist of vacancy clusterings or dislocation loops.

An Example of Computer-Controlled Batch Fabrication in the IBM-SLT Program, A. H. Johnson, *Proceedings of the National Symposium on the Impact of Batch Fabrication on Future Computers*, pp. 197-205 (April, 1965).

The IBM Systems Manufacturing Division Manufacturing Research Laboratory, located in Endicott, New York, has developed the Solid Logic Technology electronic packaging system as used in IBM's System/360. This discussion provides an example of package and manufacturing equipment design with computer control as used to combine batch fabrication with flexibility.

The modern computer must be mass produced; however, each computer must be individually tailored to meet specific customer requirements by selection of its features. This requires a program of continual improvement by changes in circuits, components, and other hardware. The package-and-manufacturing-equipment design is flexible for this continual improvement and is also able to meet the requirements of computer-controlled batch fabrication.

Excitation Operators and Intrinsic Hamiltonians, R. K. Nesbet, *Journal of Mathematical Physics* **6**, No. 4, 621-629 (April, 1965).

An operator $A^\dagger$ that satisfies $[H, A^\dagger] = \hbar\omega A^\dagger$ converts a stationary-state eigenfunction of the Hamiltonian H into another eigenfunction with energy eigenvalue increased by $\hbar\omega$. Such operators describe collective excitations of many-particle systems, and their properties can be used to construct an intrinsic Hamiltonian that is dynamically independent of the collective degrees of freedom, without introducing subsidiary conditions. The procedure developed by Lipkin, valid when $\hbar\omega$ is real and positive, is extended to make possible the construction of an intrinsic Hamiltonian when $\hbar\omega$ vanishes and $A^\dagger$ is Hermitian, and also when $\hbar\omega$ is complex. The nuclear cranking model is shown to be a special case of the proposed general method for vanishing $\hbar\omega$ in which effective moments of inertia occur as eigenvalues of linear equations. Several examples are worked out in detail, all dealing with an interacting phonon-electron system in the random-phase approximation. Results derived are the explicit screened Coulomb interaction resulting from electronic plasma excitations, a verification of the renormalized phonon frequency spectrum and phonon-electron interaction derived in the adiabatic approximation, and the resulting screened Coulomb and phonon-induced electronic interactions obtained when plasma and phonon excitations are treated simultaneously.

Fabrication and Assembly Operations—Part I: The Outlines of a Control System, C. T. Baker, *IBM Systems Journal* **4**, No. 2, 87-93 (1965).

The structure of a comprehensive control system for the fabrication and assembly industries is outlined. The system consists of several major functional components that are interconnected as an integrated whole. Component functions are described and relevant methodologies mentioned.

Fabrication and Assembly Operations—Part II: Long-Range Planning Techniques, A. B. Calica, *IBM Systems Journal* **4**, No. 2, 94-104 (1965).

An approach to the preparation and evaluation of preliminary plans for a discrete manufacturing enterprise is outlined. Some major data processing problems arise in this type of long-range planning. Mathematical techniques applicable to the solution of these problems are discussed.

Fabrication and Assembly Operations—Part III: Matrix Methods for Processing Configuration Data, P. G. Loewner, *IBM Systems Journal* **4**, No. 2, 105-121 (1965).

This discussion presents a unified method for organizing the configuration data of manufacturing files, and for generating and retrieving essential quantities from the files. The required processing operations, which include various requirements and engineering-change computations, are explained with the aid of matrix algebra. An important objective of the method is to permit a reasonably optimal balance between the bulk-storage requirements and the amount of time required for processing.

Fabrication and Assembly Operations—Part IV: Linear Programming in Production Planning, B. P. Dzielinski, *IBM Systems Journal* 4, No. 2, 122-135 (1965).

In many industries, production planning involves the allocation of various resources in the joint production of similar products. Inventory levels, labor decisions, and an economic choice of lot sizes are all influential in the planning process. Formulated in terms of mathematical programming, the economic and mathematical facets of production planning are discussed. A feasible computation technique is suggested.

Feedback System Detects 1% Amplitude Difference, P. H. Howard, *Electronics* 38, No. 10, 68-70 (May 17, 1965).

An inexpensive feedback system has been developed which permits comparison of low voltage levels without the need for precision-matched high gain amplifiers. Its application is illustrated with a portion of the circuit for an experimental character recognition device.

The Fly's-Eye Camera, J. Wuestenhagen, *Elektro-Technische Zeitung, Ausgabe B* 17, No. 10, 294-298 (May 7, 1965).

In the manufacture of semiconductor components, photographic masks are a prerequisite. By using them the transistor or diode contours are copied onto the semiconductor material. The making of good masks is greatly simplified and speeded up by the fly's-eye camera. A main component of the fly's-eye camera is the fly's-eye lens. This is made up of many small separate lenses, each of which presents a greatly reduced image of the pattern on the photographic plate. In the article the construction and manufacture of transistors is discussed. The author attempts to give an idea of the accuracy required. The application and the possibilities of the fly's-eye camera are explained.

Das Folienelement, ein neues flüssigkeitslogisches Schaltelement (The Foil Element, a New Fluid Logic Element), J. Bahr, *Elektronische Rechenanlagen* 7, No. 2, 69-78 (1965).

A new fluid logic element is described. It belongs to the group of elements with moving parts. Results of fundamental investigation are given on the method of operation, amplification and switching time, and numerous examples of application are shown.

Four-Point Probe Evaluation of Silicon N/N^+ and P/P^+ Structures, P. A. Schumann, Jr. and E. E. Gardner, *Transactions of the Metallurgical Society of AIME* 233, No. 3, 602-608 (March, 1965).

A description of a new four-point probe configuration which permits measurement of epitaxial N/N^+ or P/P^+ layer resistivity is given. An analytic solution to the potential distribution due to a point current source on a multilayered structure is briefly described. Typical solutions for this probe configuration are presented. Probe spacing, layer thickness, substrate resistivity, and substrate thickness enter into the calculation. Correction factors for typical cases are given. A brief description of the construction of a probe which can achieve a small spacing of 15μ is pre-

sented. The probe is constructed so that all points are adjustable by micrometers and the probe spacing and configuration can be easily altered. Measurements of layer resistivity with the four-point probe are compared with those taken with the three-point probe and diode-capacitance techniques. Two techniques of obtaining profiles of N/N^+ epitaxial structures are given. The reproducibility of the probe spacing and resistivity measurement is discussed. The effects upon the resistivity measurement of errors in the measurement of the layer thickness, substrate resistivity, and substrate thickness are presented.

Glass Encapsulation, J. A. Perri, *SCP and Solid State Technology* 8, No. 5, 19-21 (May, 1965).

IBM's approach to achieving lower cost and higher reliability silicon devices involves the use of thin glass films for ambient protection. These glass films are applied before dicing the wafer and eliminate the need for hermetic sealing. The influence of the glass films on device design, chip-to-substrate interconnection, and reliability are discussed.

Harmonic Generation of Hypersonic Waves in Liquids, R. G. Brewer, *Applied Physics Letters* 6, No. 8, 165-166 (April 15, 1965).

Generation of second harmonic acoustic waves in liquids at a frequency of ~ 10 Gc/sec has been observed during stimulated Brillouin scattering. The harmonic wave is believed to arise from the nonlinear acoustic response of the medium and is detected indirectly by spontaneous Brillouin scattering. While microwave acoustic nonlinearities have been observed recently in solids using other techniques, the present work represents the first measurements on liquids in the hypersonic frequency range.

High Temperature Furnace for X-Ray Diffraction of Liquid Metals, M. L. Joshi, *The Review of Scientific Instruments* 36, No. 5, 678-681 (May, 1965).

The design of a high temperature electric furnace (maximum temperature 1300°C) using pyrolytic graphite both as a heating element and as a crucible for x-ray diffraction of liquid metals is described. The usefulness of the furnace for high temperature melting metals is demonstrated by obtaining an x-ray diffraction curve of molten copper in helium atmosphere.

Influence of Longitudinal Vibrations on Image Quality, D. P. Paris and A. W. Lohmann, *Applied Optics* 4, No. 4, 393-397 (April, 1965).

The optical transfer function for incoherently illuminated objects is derived for the case of longitudinal vibrations. It becomes apparent that, contrary to the case of transverse vibrations, this transfer function cannot be separated from that for the lens alone. As an example, the influence of the longitudinal vibrations on the transfer function of a diffraction-limited lens is considered, and curves for various values of static defocusing and vibrational amplitude are shown. Under certain conditions the transfer function of a defocused lens is demonstrated to be considerably improved by introducing a certain amount of vibration. Finally, the effects of transverse and longitudinal vibrations are compared. Similar degrading effects are obtained by a transverse vibration having a vibrational amplitude A and longitudinal vibrations having an amplitude $2A/(N.A.)$, where $N.A.$ is the numerical aperture of the lens.

Isotropic Spatial Coherence Over Circular Apertures, J. V. Cornacchio, *Physics Letters* **15**, No. 4, 306-307 (April 15, 1965).

Recent interest in the coherence of laser radiation has stimulated studies concerning the measurement of partial coherence. In this article, a sufficient condition is established, in terms of the far-field intensity distribution, for the existence of isotropic spatial coherence over a circular aperture when the aperture illumination is spatially-stationary and uniform in intensity.

Low-Temperature Thermal Conductivity of Insulators Containing Impurities, Paul Erdös, *The Physical Review* **138**, A1200-A1207 (May 17, 1965).

The low-temperature thermal conductivity of an insulator with random scattering centers is evaluated under realistic boundary conditions. The Boltzmann equation is solved for this purpose. The dependence of the thermal conductivity on temperature and impurity concentration, as well as the nature of the scattering centers, is discussed.

Magnetic Birefringence of EuSe. J. C. Suits and B. E. Argyle, *Physical Review Letters* **14**, No. 17, 687-689 (April 26, 1965).

Faraday rotation and Cotton-Mouton phase difference have been measured on an EuSe single crystal at 4.2°K. The Faraday rotation at a wavelength of 755 mμ is 150,000 deg/cm and is approximately proportional to the magnetization. For EuSe at 4.2°K the Faraday rotation per decibel of optical absorption is more than an order of magnitude larger than for any other material yet measured. The Cotton-Mouton phase difference is also exceptionally large and is approximately proportional to the magnetization squared at large applied fields.

Magnetic Film Phase-Locked Oscillator, A. R. Johnson, *IEEE Transactions on Magnetics* **MAG-1**, No. 1, 26-30 (March, 1965).

This paper is concerned with the mathematical analysis of the magnetic film phase-locked oscillator which is described by a nonlinear Mathieu equation. Although there are many analyses of the PLO, they all fall short of yielding a closed-form solution which quantitatively and explicitly relates circuit and film parameters to actual operation. By establishing such a relationship, solutions for the transient response with limiting characteristics, operating frequency, and steady-state operation have been obtained.

Magnetic Parameters in NiF₂, R. J. Joenk and R. M. Bozorth, *Proceedings of the International Conference on Magnetism*, Nottingham, England, pp. 493-496 (September, 1964).

Using the Moriya model of weak ferromagnetism in NiF₂ we have derived from magnetic measurements the various parameters: the canting angle of the spin $\phi_0 = 0.39^\circ$ and the anisotropy field $H_M = 15.3$ kOe that causes it, the axial anisotropy field $H_A = 36.9$ kOe that maintains the antiferromagnetic vectors perpendicular to the tetragonal axis, the exchange field $H_E = 1130$ kOe and the splitting factor $\bar{g} = 2.31$. These quantities are obtained from meas-

urements of moment as a function of field and temperature with the additional use of the antiferromagnetic resonance data of Richards, confirmed by Wheeler, to fix the constant H_A .

Magnetic Properties of CuF₂,† R. J. Joenk and R. M. Bozorth, *Journal of Applied Physics* **36**, No. 3 (Part 2), 1167-1168 (March, 1965).

We have measured the moment of a pressed powder sample of monoclinic CuF₂ from 4.2° to 300°K in fields to 25 kOe. $\chi(T)$ indicates an AFM transition at $T_N = 69^\circ\text{K}$, and analysis gives $\bar{g} \approx 2.3$ and $\theta \approx -200^\circ\text{K}$. T_N and θ are consistent with magnetic ordering of the first kind with AFM exchange interactions J_1 (corner-bc) $\approx 34^\circ\text{K}$ and $J_2 \approx 22^\circ\text{K}$. Weak ferromagnetism of anisotropic exchange origin is expected on the grounds of symmetry; the measured ferromagnetic moment is $\sigma_0 \approx 1$ G cm³/mole, corresponding to a canting angle $\phi \approx 0.01^\circ$. Assuming magnetic dipolar anisotropy and estimating principal axes and values for the anisotropic g tensor, we find the spin axis to be about 2° from c and 99° from a in the ac plane with anisotropy field $H_A \sim 2000$ Oe, and the weak moment to be parallel to the monoclinic axis b with canting field $H_{DM} \sim 1000$ Oe. Pseudodipolar anisotropy may be expected to change the orientation, but not the order of magnitude of these fields. The uniform mode AFM resonances are not degenerate in general, but both would be expected to occur at $\nu/c \sim 9$ cm⁻¹ using these values.

† This work was supported in part by the USAFOSR of the OAR under contract AF49 (638)-1379.

Magnetische Strukturen (Magnetic structures), Harry Thomas, *Zeitschrift für angewandte Physik* **18**, No. 5/6, 404-414 (1965).

A survey is given of the theory of magnetic structures. Since magnetic structures are not invariant under time reversal, an extension of the crystallographic symmetry concept is necessary, which leads to the construction of the magnetic space groups and point groups. The structure of these groups, which are isomorphous to the antisymmetry groups ("black-and-white" groups) studied earlier by crystallographers, is represented. Applications of symmetry considerations to various problems are pointed out. The second order phase transition between the paramagnetic and the ordered state is reviewed as a breaking of symmetry, and the restrictions on the possible magnetic structures following from symmetry considerations are discussed. Further, a review is given of the theoretical methods and their limitations which have been developed for the calculation of the ground state and the temperature dependence of spin structures. Special examples of magnetization processes in spin structures are discussed. Finally, we consider the optical effects in magnetic structures and the symmetry requirements for their existence. Of particular interest is the case in which an effect is forbidden under the higher symmetry of the paramagnetic state, but becomes possible under the broken symmetry of the ordered state. This treatment can serve as a model for the classification of other physical effects induced by the magnetic order.

Magnetoacoustic Effect in Impure Metals, S. H. Liu* and A. M. Töxen, *The Physical Review* **138**, A487-A493, (April 19, 1965).

A simple but approximate theory is given for the acoustic attenuation in impure metals or semimetals in a strong

magnetic field. In the extreme quantum case, the acoustic attenuation is an oscillatory function of the magnetic field. It is shown that the qualitative nature of the oscillation depends on two parameters $\omega_q\tau$ and q_zl , where ω_q is the phonon frequency, τ the mean collision time, q the phonon wave vector, and l the electron mean free path, and the z axis is chosen as the direction of the field. For $\omega_q\tau \gg 1$ the quantum oscillation is gigantic, as pointed out by Gurevich, et al. The large absorption occurs when the electrons near the Fermi level drift in phase with the sound. In the intermediate region where $\omega_q\tau \lesssim 1$ but $q_zl \gg 1$, the oscillation is still giant in the sense that only one quantum level contributes to the absorption, but the oscillation is purely a density-of-states effect. When $q_zl \lesssim 1$, all levels contribute to the absorption, and the oscillation is of the de Haas-van Alphen type. The effect of varying the direction of sound propagation relative to the field is also discussed in all three regions.

* Present address: Department of Physics, Iowa State University, Ames, Iowa.

Mathematical Programming, R. E. Gomory, *American Mathematical Monthly* **72**, No. 2 (Part II), 99-110 (February, 1965).

This is an article surveying the present state of mathematical programming.

Mathematical Programming and Theory of Structures, William Prager, *Journal of the Society of Industrial and Applied Mathematics* **13**, No. 1, 312-332 (March, 1965).

An analogy is established between problems concerning flows in networks and problems of plastic analysis and design of certain structures. As is illustrated by examples, this analogy provides opportunities for the mutual stimulation of the two fields.

Message Framing and Error Control, A. H. Frey, Jr., *IEEE Transactions on Military Electronics* **MIL-9**, No. 2, 142-147 (April, 1965).

Two problems which arise in the transmission of digital data are message framing and error control. A technique has been developed whereby polynomial coding can be used simultaneously for both error detection and message framing. With this technique, encoded data blocks can be transmitted asynchronously without incorporating any special signals or bit patterns for start-of-message and end-of-message indications. Erroneously received blocks are automatically deleted from the accepted data stream.

The standard systems use a special signal for a start-of-message (SOM) indication at the beginning of each block of data, and independently create and detect a specified format (usually based on parity check sums) to determine when errors have occurred in transmission of the data. In order to achieve high reliability, it is necessary to use sophisticated techniques and to devote a large number of transmitted digits to each of these functions. By considering these two problems together, a technique which provides a solution to both was found. This technique uses fewer bits than would be required by many conventional approaches to framing to get the same reliability. The error-detection

capability which is included is so strong that the mean time between undetected errors is usually dependent on equipment reliability rather than on channel error statistics.

Multi-Stage Cutting Stock Problems of Two and More Dimensions† P. C. Gilmore and R. E. Gomory, *Operations Research* **13**, No. 1, 94-120 (January/February, 1965).

The problem of generating all possible patterns for two-dimensional stock cutting problems appears to be extremely difficult even in the special case of cutting rectangles from rectangles. However, for a class of problems frequently encountered in industry, the multi-dimensional problem becomes in fact a multi-stage one. In treating practical cutting problems, one often encounters additional conditions which affect the solution. An example of this occurs in the cutting of corrugated boxes which involves an auxiliary sequencing problem. This problem is discussed in some detail, and a solution described, for the sequencing problem under given simplifying assumptions.

† This research was supported in part by the Office of Naval Research under Contract No. Nonr 3775(00), NR 047040.

Nomographs from Experimental Data, A. S. Bolthouse and J. F. Krzan, *Machine Design* **37**, No. 9, 171-173 (April 15, 1965).

The art of nomography was employed to develop a circular slide rule to provide ballistics data for performing strategic bombing. The procedure entailed plotting the present tabular data as families of curves, constructing nomographs of these curve families using the technique of John Baude, reported in *Machine Design*, May 1952, and finally transferring these nomograph scales to a circular rule. When the first nomograph scale had been completed, the scales were checked for accuracy. It was discovered that a considerable error existed particularly for those scale settings corresponding to extreme values. This error was almost one order of magnitude larger than that which was acceptable. This paper describes the technique which evolved to reduce this error to acceptable levels. This technique is an extension of that previously described by Baude.

On Application of Kubo's Theory to Transport and Relaxation Phenomena in Solutions, Harold L. Friedman, *Zeitschrift für Physicalische Chemie* **228**, No. 5/6, 318-330 (1965).

We review Kubo-type expressions for transport coefficients, giving expressions for admittance and susceptance functions in terms of the propagators and distribution functions of the corresponding equilibrium systems. These results are applicable to those systems for which a microstate can be specified as a point in a classical location-momentum phase space. We discuss the application of these equations to the problem of calculating the concentration dependence of several properties of solutions: the conductance and Hall effect in ionic solutions, and the dielectric properties of solutions of polar molecules. In these applications the propagators and distribution functions may be averaged over the phases of the solvent molecules.

The calculation of the effect of the interactions among

solute species upon observable properties may often be simplified by also averaging the propagators and distribution functions over the momenta of the solute molecules. Then the role of the generalized Liouville equation, which determines the effect of solute-solute interactions on the solvent-averaged propagators in the complete phase space, is played by the Smoluchowski equation, which determines the effect of these interactions on the resulting solvent-averaged propagators in location space.

On the Construction of Symmetric Difference Operators for Square and Cubic Lattices, B. Meister and W. Prager, *Zeitschrift für angewandte Mathematik und Physik (ZAMP)* **16**, No. 3, 403-410 (1965).

The paper presents a method of deriving certain finite difference analogs to linear differential operators for functions of two or three variables. The method furnishes not only Lagrangian and Hermitian difference expressions of various degrees of accuracy but also their leading error terms.

On the Relation between Integer and Noninteger Solutions to Linear Programs,† R. E. Gomory, *Proceedings of the National Academy of Sciences* **53**, No. 2, 260-265 (February, 1965).

This paper contains theorems and a calculation linking the solution of the ordinary linear programming problem to the solution of the corresponding integer programming problem.

† This work was supported in part by the Office of Naval Research under contract Nonr 3775(00), NR 047040.

Open-base Breakdown in Diffused N-P-N Junction Transistors, D. P. Kennedy and R. R. O'Brien, *International Journal of Electronics* **18**, No. 2, 133-145 (February, 1965).

A one-dimensional analysis is presented on the open-base breakdown characteristics of diffused *n-p-n* transistors. From breakdown voltage measurements upon selected devices—in conjunction with breakdown voltage calculations—"effective" values are established for the ionization rate of electrons in germanium and silicon *p-n* junctions, when biased substantially below avalanche breakdown. These "effective" electron ionization rates are used to calculate the open-base breakdown voltage for transistors exhibiting a large collector punch-through voltage; such calculations are graphically illustrated throughout a range of parameters applicable to many practical situations. A discussion is also presented on the influence of an abrupt conductivity increase within the collector junction space-charge layer, of the type encountered in an idealized epitaxial structure.

Optical Flux Analysis in a Cathode Ray Tube Scanner System, C. Y. Ho, H. P. Domabyl,* and W. C. Naylor, *Applied Optics* **4**, No. 4, 373-377 (April, 1965).

This paper describes the mathematical analysis of the light flux behavior in an optical scanner system. The system consists of a cathode ray tube (CRT) light source, a focusing lens system, a semidiffusing document plane, and several light-collecting photomultiplier tubes (PMTs). The flux intercepted by the PMTs is calculated as a function of: the position intensity distribution of the CRT source spot, the lens system's focusing, absorbing, and vignetting properties, the document plane's reflecting, diffusing, and absorbing properties, and the positions and orientations of the PMTs. The FORTRAN program which implemented these concepts is discussed.

* Present address: Ampex Corporation.

Optimal Control of Markov Processes with Incomplete State Information, K. J. Åström, *Mathematical Analysis and Applications* **10**, No. 1, 174-205 (February, 1965).

Transition probabilities of the Markov process are functions of the control variables. The process is observed through a noisy channel, which is referred to as incomplete state information. An instantaneous cost function is associated with time, state and control variable. The problem is to find a control law such that the mathematical expectation of the sum of the instantaneous costs is minimal. The control law is such that the value of the control variable time t is a function of all previous observations. By introducing the conditional probabilities as hyperstates, dynamic programming can be applied. A functional equation for the loss function is derived and analyzed.

It is shown that the optimal control law can be expressed as $u = u(w, t)$ where w is the hyperstate which is a function of the observed outputs. The function $u = u(w, t)$ can be calculated a priori, without any knowledge of the actual outputs of the system, as the solution of an associated problem with complete state information. The function w which is a function of the observations must obviously be calculated in real time, as the process develops. We can thus divide the problem in the same way as is done in the well-known linear quadratic case.

The problem is also compared with two associated problems, namely those of complete state information and of no state information at all. The latter problems are easier to solve, and the solutions will provide bounds for the solution of our problem. The comparison will also make it possible to associate cost with state information. This provides connection between information theory and the theory of stochastic optimal control.

Optimality of Intermediate-Thrust Arcs of Rocket Trajectories, H. M. Robbins, *AIAA Journal* **3**, No. 6, 1094-1098 (June, 1965).

A new necessary condition is derived for the optimality of intermediate-thrust arcs of rocket trajectories in vacuum. The new necessary condition, together with previously known necessary conditions, ensures the absolute optimality of "sufficiently short" intermediate-thrust arcs. For inverse-square central fields, the new condition reduces to a requirement that the primer-vector must point inward; its radial component must be negative. Intermediate-thrust arcs which satisfy the new condition cannot join to arcs of a

finite maximum thrust, nor join directly (without impulses) to arcs of zero thrust, except in a very restricted set of special cases. They are, therefore, of theoretical rather than practical importance.

The Photo Recorder—A Method for the Analysis of Rapid Movements of Light Mechanical Parts, R. Hartwig, *Elektronik* 14, No. 4, 113-115 (April, 1965).

An electronically controlled mechanical-optical recording method is described which, by its high resolving power in time and distortionless reproduction, lends itself particularly well to the analysis of motion on light-weight specimens which move in a transitory, rotational, or plane manner. "Aimed" recordings at preselectable instants of time and over preselectable intervals of time allow an accurate investigation of individual motional phases.

A Photoisomerization Reaction of Cyclic Ketones in the Liquid Phase, R. Srinivasan and S. E. Cremer, *Journal of the American Chemical Society* 87, No. 8, 1647-1651 (April 20, 1965).

It has been found that six-, seven-, and eight-membered cyclic ketones, when irradiated as pure liquids with light of 3130 Å, undergo a ring contraction reaction to give the 2-methyl derivative of the cyclic ketone with one less carbon. The reaction accounts for 6% of the cyclohexanone that undergoes photolysis but only 0.2% in cycloheptanone. A variant of this reaction gives 2-n-propylcyclopentanone in the photolysis of cyclooctanone. In cyclohexanone the reaction has a quantum yield of 0.03. This value decreases in solutions of cyclohexanone in cyclohexane. At a given concentration, the addition of cyclohexane has no effect on the yield. Substitution of the ring by a methyl group in the 2-position seems to obscure the reaction, while in the 3-position only one of the two possible dimethylcyclopentanone is formed. In the photolysis of cyclohexanone-2,2,6,6-d₄, the product corresponded to COCH(CHD₂)CH₂CH₂CD₂. The reaction is believed to involve the transfer of a proton from the 3- to the 2-position in a configuration in which the ring is substantially intact.

Polarization of Anthracene Fluorescence by One and Two Photon Excitation, W. L. Peticolas, and K. E. Rieckhoff, *Physics Letters* 15, No. 3, 230-231 (April 1, 1965).

The polarization of the fluorescence of a 2×10^{-3} molar solution of anthracene in EPA at liquid nitrogen temperature excited by light from a giant-pulsed ruby laser has been measured to determine the mechanism of the two photon excitation of anthracene. The results show that the excitation takes place via an intermediate state due to the $p \cdot A$ term of the Hamiltonian (Goepfert-Mayer process) rather than directly due to the A^2 term as proposed recently by Ianuzzi and Polacco. The ratio of the two cross section to the laser flux δ was also measured and found to be $\delta = 0.9 \times 10^{-51}$ cm⁴ sec in close agreement with the value found by Hall for the anthracene crystal.

Preparation and Magnetic Properties of Nickel-Cobalt-Oxygen Spinels, M. W. Shafer, *Proceedings of the International Conference on Magnetism*, Nottingham, England, pp. 468-471 (September, 1964).

Nickel cobalt spinels with compositions between Co₃O₄ and Ni_{1.4}Co_{1.6}O₄ have been prepared under high oxygen pressure, and the phase relationships showing the conditions under which single phase spinel compositions can be prepared have been determined. Lattice parameters were measured and despite the fact that Ni²⁺ is slightly smaller than Co²⁺, a linear increase from 8.083 for Co₃O₄ to 8.116 for NiCo₂O₄ was observed. This is interpreted as due to Ni²⁺ replacing the spin paired Co³⁺ on the B sites. Magnetization measurements confirmed antiferromagnetism in Co₃O₄ and showed that a ferrimagnetic state is obtained with nickel additions. Curie temperatures reached a maximum of 240°C for a composition of NiCo₂O₄ and began to drop with further nickel additions. Saturation moment data were used in attempts to predict a model for the ionic distribution. The most likely one, where all Ni²⁺ goes on the B sites, is not consistent with the Néel antiparallel theory.

Remark on Romberg Quadrature, A. M. Krasun* and W. Prager, *Communications of the Association for Computing Machinery* 8, No. 4, 236-237 (April, 1965).

A modified form of Romberg quadrature is described, which is less sensitive to the accumulation of rounding errors than the customary one.

* Present address: Brasenose College, Oxford, England.

Research Group Implements System Approach to Manufacturing, A. H. Johnson, *Automation* 12, No. 5, 72-75 (May, 1965).

Imagine that you must provide an optimum system for the manufacture of a line of products that share many characteristics but which eventually are "customized." Changes in order quantities and mix can occur at any time. And Engineering has notified you that they intend to change the product design whenever advancements in technology warrant it. Just such a set of conditions faced the research group of an IBM division responsible for automating the manufacture of printed circuit products. Their solution, described herein, was to use high-production type automated equipment for the standard operations, and flexible, numerically controlled devices for the specialized manufacturing and testing steps. The whole complex—including production scheduling, product design, manufacturing, testing, quality control, and management reporting—is computer directed.

Secondary Key Retrieval Using an IBM 7090-1301 System, A. D. Lin and D. R. Davis, *Communications of the Association for Computing Machinery* 8, No. 4, 243-246 (April, 1965).

The secondary key retrieval method involves the preparation of secondary storage lists from primary data records. Search requests are satisfied by logical operations on appro-

appropriate lists, producing a complete set of addresses of primary records relevant to the request. Experimental results are presented and a comparative analysis is given.

Self-Similar Error-Clusters in Communication Systems and the Concept of Conditional Stationarity, B. B. Mandelbrot, *IEEE Transactions on Communication Technology* COM-13, No. 1, 71-90, (March, 1965).

The purpose of this paper is twofold. From the viewpoint of communications engineering, it presents a model of certain random perturbations that appear to come in clusters, or bursts. This will be achieved by generalizing the concept of "self-similarity" to stochastic point processes in continuous time. The resulting mechanism presents fascinating peculiarities from the mathematical viewpoint; in order to make them more palatable, as well as to provide background material for forthcoming papers on excess noise and turbulence, the basic concept of conditional stationarity will be discussed in greater detail than would be strictly necessary from the viewpoint of the immediate engineering problem of errors of transmission.

A Small Computer for the Direct Processing of FORTRAN Statements, A. J. Melbourne and J. M. Pugmire, *The Computer Journal* 8, No. 1, 24-27 (April, 1965).

A small computer with a microprogrammed FORTRAN compiler is described. A comparison is made with a conventional computer of similar speed which uses a software compiler.

Some Design Techniques for Fluid-Jet Amplifiers, C. P. Wright, *Transactions of the ASME Journal of Basic Engineering* 87, Series D, No. 1, 67-73 (March, 1965).

The operation of the fluid-jet amplifier is described briefly. A performance criterion is developed for the amplifiers, and design techniques are presented which constrain the amplifier to exhibit the decision function. The techniques involve the superposition of a bias on the amplifier which alters its switching characteristics. In addition, a stability criterion for amplifier operation is developed and its uses are suggested. Some effects of internal geometry variations are also discussed.

Spectral Theory for Operators Generated by Elliptic Boundary Problems with Eigenvalue Parameter in the Boundary Conditions, I. J. Ercolano and M. Schechter,* *Communications on Pure and Applied Mathematics* 18, No. 1 and 2, 83-105 (February/May, 1965).

In this paper we propose to study some spectral problems in the theory of general boundary problems for symmetric partial differential operators. Our method consists of putting these problems in a Hilbert space framework in order to use the known results from that theory. The principal tool in our development is an a priori estimate with which we are able to prove a regularity theorem for a class of functions

corresponding to a variety of general self-adjoint eigenvalue problems, where the eigenvalue parameter may appear either in the domain or boundary conditions.

The regularity theorem, when interpreted in a more general setting than Hilbert space, leads to a topological vector space which has been termed "nuclear." In this space, we are able to supplement the classical spectral theory by proving the existence of a spectral function for each problem under consideration, and a Green's function for appropriately related problems.

* Courant Institute of Mathematical Sciences, New York University.

Study of Electronic Band Structure by Tunneling Spectroscopy: Bismuth, L. Esaki and P. J. Stiles, *Physical Review Letters* 14, No. 22, 902-904 (May 31, 1965).

By means of the conductance vs voltage plot, we have detected many bands in bismuth, most of which have never been seen with other experimental methods. This demonstrates that this technique of tunneling spectroscopy has great potential for band-structure studies in semimetals and degenerate semiconductors.

Symbolic Computation of f and g Series by Computer, P. Sconzo, A. R. LeSchack and R. Tobey, *Astronomical Journal* 70, No. 4, 269-271 (May, 1965).

A digital computer program, capable of generating and manipulating symbolic mathematical expressions for the coefficients of the f and g series of Keplerian motion, is discussed. Terms up to the 23rd order are given as polynomials in the local invariants μ , σ , and ϵ used by Stumpff.

Theta Modulation in Optics, J. D. Armitage and A. W. Lohmann, *Applied Optics* 4, No. 4, 399-403 (April, 1965).

The experiments reported in this paper are similar to the famous Abbe experiments. However, they were done for quite different reasons, namely, to perform certain information processing operations by optical means. Our technique, called theta modulation, allows production of a color image from a black and white film, on which the color object is recorded in encoded form. Furthermore, nonlinear characteristics (H & D curves) of any shape can be realized. A special application of theta modulation, called multiplex storage, will be described. By this technique, more than one image can be recorded in the same area on a piece of film. Subsequently, the individual images can be recovered with a minimum of crosstalk.

Three-Eyepiece Microscope Digitizes 0.0001-Inch Motion, Karl Hermann, *Machine Design* 12, No. 37, 33 (May 27, 1965).

Signals generated by a microscope detector tell how far and in what direction a diffraction grating travels. Intended for use in an optical control system, the prototype detector can accurately measure linear motion as small as 0.0001 in. and angular motion of 20 sec.

Topological Entropy, R. L. Adler, A. G. Konheim, and M. H. McAndrew,* *Transactions of the American Mathematical Society* **114**, No. 2, 309-319 (February, 1965).

The purpose of this work is to introduce the notion of entropy as an invariant for continuous mappings of a compact topological space into itself. Section 1 contains the definition of the notion of entropy; section 2 deals with its general properties; section 3 deals with the computation of entropy in metric spaces; section 4 discusses the measure theoretic background of this concept and comparisons between measure theoretic and topological entropy along with some unsolved problems; and section 5 indicates that entropy has an abstract formulation applicable to a wide variety of mappings.

* Present address: Mathematics Department, University of Washington, Seattle.

A Unique Illustrator's Complex, R. A. Harms, *Graphic Science* **7**, No. 5, 34 (May, 1965).

This article describes a unique reference table/storage area/drawing board designed by the author to meet requirements of an engineering illustrator.

Uniqueness in the Linear Theory of Viscoelasticity, F. Odeh and I. Tadjbakhsh, *Archive for Rational Mechanics and Analysis* **18**, No. 3, 244-250 (1965).

Two new uniqueness theorems in the dynamic theory of viscoelasticity are given. In both theorems the material is allowed to be inhomogeneous and the usual symmetries of the relaxation tensor are not assumed. Moreover, the assumption of initial strong ellipticity of this tensor, rather than its positive definiteness, is shown to be sufficient for uniqueness.

Using Single-Sided Non-Parametric Tolerance Limits and Percentiles, I. Belson and K. Nakano,* *Industrial Quality Control* **21**, No. 11, 566-569 (May, 1965).

The use of tolerance limits and the estimation of percentiles are an important part of engineering statistics. If the normal or other known distributions can be used, the analysis is quick and efficient. Many times this cannot be done because of insufficient data. Yet the need for analysis still exists. It can be satisfied in many cases by using non-parametric tolerance limits as described in this article.

* Lockheed Missile & Space Co., Sunnyvale, California.

A Wedge-Flow Approach to Lubrication Theory, W. E. Langlois, *Quarterly of Applied Mathematics* **23**, No. 1, 39-46 (April, 1965).

A theory of fluid-film lubrication is developed from an assumption of local wedge-flow, rather than local paralleled-channel flow. This leads to a generalization of the Reynolds

lubrication equation governing the pressure. A refinement of lubrication theory does not necessarily follow: unlike the paralleled-channel case, the stress field may differ significantly from an isotropic pressure, so that imposing ambient conditions on the bearing periphery does not always yield boundary conditions for the pressure equation. If the bearing slope differs appreciably from zero only in the film interior, consistent boundary conditions are once more available.

The World's Fair Machine Translator, D. M. Bowers and M. B. Fisk, *Computer Design* **4**, No. 4, 16-29 (April, 1965).

The Russian-to-English machine translation system which is part of the exhibit at the IBM pavilion at the New York World's Fair is described. The system configuration and philosophy, the dictionary organization and methodology and the production operating mode are discussed.

Letters to the Editor

Cr³⁺-Cr³⁺ Pairs in Garnets, G. Burns, E. A. Giess and K. W. Blazey, *Bulletin of the American Physical Society Series II* **10**, No. 3, 329 (1965).

Das Deutsche Elektronensynchrotron "DESY" (The German Electron-synchrotron "DESY"), P. Erdös, *Neue Zürcher Zeitung, Technik*, No. 2470, 87 (June 9, 1965).

Junction Heating in GaAs Injection Lasers, K. L. Konnerth, *Proceedings of the IEEE* **53**, No. 4, 397-398 (April, 1965).

New Replicating Technique for Electronmicrofractography, D. F. Solum, *The Review of Scientific Instruments* **36**, No. 5, 701 (May, 1965).

Preparation of Atomically Clean Surfaces of Si and Ge by Heating, F. Jona, *Applied Physics Letters* **6**, No. 10, 205-206 (May 15, 1965).

Production of Seed Crystals by Pulling from the Melt, D. D. Roshon, Jr., *Review of Scientific Instruments* **36**, No. 5, 712 (May, 1965).

A Simpler Transistor Model, R. H. F. Lloyd, *Proceedings of the IEEE* **53**, No. 5, 527-528 (May, 1965).

Thermal Decomposition of Bicyclo [1. 1. 0] butane, R. Srinivasan, A. A. Levi, and I. Haller, *Journal of Physical Chemistry* **69**, No. 5, 1775 (May, 1965).

Transfer of Vibrational Energy from Internally Converted States, I. Haller and R. Srinivasan, *Journal of Chemical Physics* **42**, No. 8, 2977 (April 15, 1965).